S P E C I F I C A T I O N

METHODS AND APPARATUS FOR DUAL MODE OPERATION IN A WIRELESS COMMUNICATION SYSTEM

A1

Field of the Invention

The present invention relates to wireless communication systems. More particularly, the present invention pertains to methods and apparatus for dual mode operation in a wireless communication system.

Background of the Invention

The third generation (or "3G") of wireless communication services promises to bring unity to a fractured worldwide cellular market. 3G systems will permit seamless travel not presently available in the splintered U.S. mobile telephone service. In addition, 3G systems promise a wide array of high-speed broadband data transmission and processing, including video, on-board navigation, and Internet access.

One wireless standard designed to support 3G services is cdma2000™, defined by the ITU in its IMT-2000 vision. Phase one of the cdma2000 standard effort, known as "1xRTT" (i.e., Radio Transmission Technology), has already been completed and published by the Telecommunications Industry Association (TIA). 1xRTT refers to cdma2000 implementation within existing spectrum allocations for cdmaOne – 1.25 MHz carriers. The technical term is derived from N = 1 (i.e., use of the same 1.25 MHz carrier as in cdmaOne) and the "1x" means one time 1.25 MHz. 1xRTT is backward compatible with cdmaONE networks, but offers twice the voice capacity, data rates of up to 144 kbps, and overall quality improvements.

Also employing a 1.25 MHz channel is the High Data Rate (HDR) technology. HDR is RF compatible with cdmaOne and 1xRTT systems and permits side-by-side deployment of

transmitters and antennas in existing CDMA towers. Unlike 1xRTT, which is optimized for circuit switched services, HDR is spectrally optimized for best effort packet data transmission. HDR delivers very high-speed CDMA wireless Internet access at peak data rates greater than 1.8 Megabits per second. Notably, unlike 1xRTT, the control and data channel in an HDR carrier are time multiplexed.

Because of its high speed Internet access, it is preferable to conduct data communications over an HDR carrier, rather than on a 1xRTT carrier. Nevertheless, because HDR is packet based, it does not accommodate real time applications very well. Thus, a user of an HDR carrier who wishes to place a voice communication would need to use a carrier such as 1xRTT. U.S. Patent Application Ser. No. 09/474,056, filed December 28, 1999, which is fully incorporated herein by reference, discloses a hybrid network supporting both 1xRTT and HDR carriers. The hybrid network coordinates communication over either the 1xRTT or the HDR carrier as circumstances dictate. Such a hybrid network, however, requires the changes necessary in 1xRTT and HDR protocol to support this coordination.

Summary of the Invention

In accordance with a first aspect of the invention, methods and apparatus are provided for transferring communications at a terminal within an overlapping coverage area having an all-services carrier and a best-efforts carrier, wherein the all-services carrier supports real-time and non-real-time services and the best-efforts carrier supports only non-real-time services. In one embodiment, the all-services carrier is a 1xRTT carrier and the best-efforts carrier is an HDR carrier. (Note: There are always two carriers for both 1xRTT and HDR: one for the forward link and one for the reverse link. As used herein, "carrier" will collectively refer to both the forward and reverse link carriers.)

In a preferred embodiment, a terminal tunes to a HDR carrier when in an idle state. The terminal periodically scans a 1xRTT carrier for pages, SMS and other information such as information sent via wavelength communications. Should the scan detect an incoming communication on the 1xRTT carrier, any existing HDR packet data communication is terminated so that the terminal may tune to the 1xRTT carrier to receive the incoming communication. If the coverage area does not support an HDR carrier, the terminal tunes to the 1xRTT carrier and periodically scans for an HDR carrier.

In another preferred embodiment, a terminal is provided with a transceiver capable of being tuned to a HDR carrier or to a 1xRTT carrier, and a processor capable of tuning the transceiver based on the type of communication the terminal is engaged in. Thus, the processor tunes the transceiver to a HDR carrier for non-real-time packet data communications, and to a 1xRTT carrier for voice communications or packet data communications.

In accordance with another aspect of the invention, a wireless communications network includes an HDR carrier for non-real-time packet data communications, a 1xRTT carrier for 1xRTT communications or packet data communications, and a plurality of terminals. Each terminal is provided with a transceiver capable of being tuned to a HDR carrier or to a 1xRTT carrier, and a processor capable of tuning the transceiver based on the type of communication the terminal is engaged in, such as the terminal described above.

As will be apparent to those skilled in the art, other and further aspects and advantages of the present invention will appear hereinafter.

Brief Description of the Drawings

Preferred embodiments of the present invention are illustrated by way of example, and not by way of limitation, in the figures of the accompanying drawings, in which like reference numerals refer to like components, and in which:

Fig. 1 is a block diagram of both a 1xRTT and an HDR network having an overlapping coverage area.

Fig. 2 is a communication flow diagram according to one embodiment of the invention.

Fig. 3 is a communication flow diagram according to one embodiment of the invention.

Fig. 4 is a communication flow diagram according to one embodiment of the invention.

Fig. 5 is a block diagram illustrating a terminal capable of dual mode operation in accordance with one embodiment of the invention.

Detailed Description of the Preferred Embodiments

Figure 1 illustrates coverage area 100 supported by both a 1xRTT and an HDR network. Users at terminals such as a laptop computer 110 having a wireless transceiver or a handset 115 may communicate over either an HDR carrier 120 or a 1xRTT carrier 125 as long as the terminal is configured for dual mode operation. The 1xRTT carrier 125 carries 1xRTT communications, which may include voice, packet data, or other multi services such as Short Message Services (SMS) or broadcast information services. The HDR carrier 120 is a carrier used only for the transmission of non-real-time packet data. An HDR transmitter 130 under the control of an HDR base station controller 135 transmits the HDR carrier 120. The HDR base station controller 135 couples to a packet data core network 155. Packet data from the Internet 150 couples through the packet data core network 155 to the HDR base station controller and ultimately to the terminals 110 and 115.

Voice communications are carried only by the 1xRTT carrier 125 transmitted by a 1xRTT transmitter 131 under the control of a 1xRTT base station controller 136. A mobile switching center 140 connects a public switched telephone network (PSTN) 145 with the 1xRTT base station controller 136. Packet data from the Internet 150 couples to the mobile switching center 140 through an ISP server 160. Alternatively, packet data can be connected directly to BSC 136 through the packet data core 155.

Unlike the hybrid network disclosed in the above-incorporated application Ser. No. 09/474,056, the 1xRTT and HDR carriers are separate and independent. Rather than having the network supply the coordination between these carriers, the present invention uses intelligence supplied by the terminals to control whether communications will be received on a given carrier. Thus, the present invention may be denoted a "terminal-centric" approach in contrast to the "network-centric" approach disclosed in application Ser. No. 09/474,056.

Towards this end, the present invention has two main embodiments: one in which packet data communications are not transferred between the HDR and 1xRTT carriers, and one in which packet data communications are transferred between the HDR and 1xRTT carriers using standard 1xRTT packet data hand-over procedures. It should be noted that acquiring a carrier signal usually encompasses the steps of tuning the terminal to the correct frequency, synchronizing the terminal timing to the correct network timing, and then

registering with the network. This process is well known in the art, however, and the invention does not depend on any particular method of acquiring a carrier. Therefore, in the discussion below, the process of acquiring a carrier will simply be referred to as tuning the terminal to the carrier. The first embodiment will now be described further:

No Packet Data Hand-Over Embodiment

In this embodiment the terminal tunes to the HDR carrier as the default carrier if this carrier is available. A sample communication flow procedure is illustrated in Figure 2. Here, the HDR carrier 120 is available so that the terminal "camps on" and monitors this channel. The user then initiates one or more non-real-time packet data communications over the HDR carrier 120 at step 200. As demonstrated at steps 205 and 210, the terminal may periodically place the HDR packet data communication on hold and tune to the 1xRTT carrier to look for incoming 1xRTT communications directed to the terminal over the 1xRTT carrier. At step 205, because no voice communications were detected on the 1xRTT carrier, the terminal returns to the HDR carrier and resumes the non-real-time packet data communication. At step 210, however, the terminal detects an incoming 1xRTT communication on the 1xRTT carrier. Thus, the terminal automatically discontinues the HDR packet data communication and establishes an active 1xRTT communication. Upon termination of the 1xRTT communication at step 215, the terminal tunes to the HDR carrier to re-establish the HDR packet data communication. In an alternative embodiment, the terminal may query the user whether or not to accept the incoming 1xRTT communication at step 210. In such a case, only an affirmative response by the user would lead to establishment of the active 1xRTT communication. Otherwise, the terminal would return to the HDR carrier and re-establish the HDR packet data communication. For example, where the incoming 1xRTT communication is a voice communication, the terminal tunes to the 1xRTT carrier and establishes a voice communication. Once the voice communication is terminated, the terminal tunes to the HDR carrier to re-establish any HDR packet data communications that the terminal was previously engaged in.

When a user of the terminal initiates a 1xRTT communication, such as a voice communication, the communication must be carried out over the 1xRTT carrier. This can be

illustrated in figure 2. Therefore, if a non-real-time packet data communication is in progress over the HDR carrier (step 200) when the user initiates a voice communication, then the non-real-time packet data communication must be put on hold while the terminal is tuned to the 1xRTT carrier (step 210). The voice communication is then commenced on the 1xRTT carrier. Upon termination of the voice communication, the terminal is tuned to the HDR carrier and the non-real-time packet data communication is re-established (step 215).

Note that the above scenarios require the terminal to be in the footprint or coverage area of both an HDR and a 1xRTT transmitter. Figure 3 presents the communication flow scenario if an HDR carrier is unavailable. Because the default mode is to camp on the HDR carrier, the terminal will periodically scan for the availability of the HDR carrier at steps 220 and 230. At step 220, no HDR carrier is available so the terminal must re-tune to the 1xRTT carrier. However, at step 230, the terminal, having moved into an area of HDR coverage, detects and tunes to the HDR carrier. Note that if a 1xRTT packet data communication had been established prior to step 230, this 1xRTT packet data communication would have to be terminated before the terminal could camp on the HDR carrier. Subsequent to step 230, the terminal could re-establish the packet data communication on the HDR carrier.

1xRTT Packet Data Hand-over Embodiment

This embodiment differs from the previously-described embodiment by employing basic 1xRTT packet data hand-over procedures to maintain continuity of packet data communications between the HDR and 1xRTT carriers. Figure 4 shows the communication flow for a transition from HDR to the 1xRTT carrier. At step 250, the terminal establishes an HDR packet data communication. At step 260, the terminal tunes to the 1xRTT carrier to establish a 1xRTT communication. The impetus to tune to the 1xRTT carrier may have resulted from a periodic scan such as discussed with respect to Figure 2 or may have resulted from the user desiring to place a voice communication. Because the terminal is tuned to the 1xRTT carrier while an active HDR packet data communication is in progress, the terminal sends a hand-over request to the network prior to step 260. As the terminal tunes to the 1xRTT network, a standard 1xRTT packet hand-over procedure is followed to transfer the packet data communication to the 1xRTT carrier. Thus, at step 270, an active 1xRTT and an

active data communication are present on the 1xRTT carrier. Upon termination of the 1xRTT communication at step 280, the terminal again sends a 1xRTT hand-over request to the network with information about the target HDR base station controller.

Just as discussed with respect to Figure 3, the terminal may be in an area not supporting an HDR carrier. The terminal would, while camping on the 1xRTT carrier, periodically scan for the presence of an HDR carrier. Upon detecting the HDR carrier, should the terminal have an active 1xRTT packet data communication in progress, it will send a 1xRTT hand-over request to the network as discussed with respect to Figure 4. The request should contain information about the target base station controller. In addition, point-to-point protocol (PPP) state information will be transferred between the HDR and 1xRTT base station controllers. Upon acknowledgement from the network of the hand-over request, the terminal tunes to the HDR carrier and the packet data communication resumes as a non-real-time packet data communication.

Figure 5 illustrates an example architecture for a terminal in accordance with one embodiment of the invention. Terminal 500 comprises an antenna 502 for receiving Radio Frequency (RF) carrier signals. For example, antenna 502 may receive 1xRTT carrier 125 signals and HDR carrier 120 signals. Antenna 502 is also configured to transmit RF signals that are encoded with data to be communicated to the network. Duplexer 504 is coupled to antenna 502 and switches the antenna between receive and transmit paths within terminal 500.

The receive path comprises a Low Noise Amplifier (LNA) 506 that amplifies the received RF carrier signals to a suitable level for further processing. The amplified signal is then passed to a demodulation circuit 510. In a typical receive path, demodulation circuit 510 will consist of two stages. In the first stage, an RF mixer 512 mixes the received RF signal down to an Intermediate Frequency (IF) signal by mixing the RF received signal with an RF Local Oscillator (RFLO) 522 signal. In the second stage, the IF signal is mixed with an IFLO 524 in order to step the IF signal down to a baseband signal. The baseband signal is then coupled to a processor 526 that decodes any data contained in the baseband signal. Generically, processor 526 is typically referred to as a baseband processor.

Conversely, in the transmit path, data to be communicated to the network is encoded onto a baseband signal by processor 526 and coupled to modulation circuit 520. Modulation

circuit 520 mixes the baseband signal up to an IF signal in mixer 518 by mixing the baseband signal with IFLO 524. The IF signal is then mixed up to an RF signal in mixer 516 by mixing the IF signal with RFLO 522. The RF signal is then amplified by a Power Amplifier (PA) 508 to ensure that the RF signal transmitted by antenna 502 is of sufficient power.

In the transmit path, RFLO 522 must be tuned to produce the correct RF carrier signal. For example, if terminal 500 is communicating non-real-time packet data, then RFLO 522 must be tuned to produce an RF signal with the appropriate HDR carrier frequency. If, on the other hand, terminal 500 is engaged in voice communication, then RFLO must be tuned to produce a RF signal with the appropriate 1xRTT carrier frequency.

Figure 5 illustrates that in a typical embodiment, processor 526 controls the tuning of RFLO 522. Processor 526 also tunes IFLO 524 if required; however, IFLO 524 may remain at the same frequency with only RFLO 522 being tuned. In fact, those skilled in the art will understand that some embodiments of terminal 500 may not include IFLO 524 or mixers 514 and 518. In this case, RF mixer 512 converts the received RF carrier directly to baseband, and RF mixer 516 converts the baseband signal coupled from processor 526 directly to an RF signal. This type of architecture is termed direct conversion architecture.

Regardless of the specific architecture, the transmit and receive paths are typically included in one unit termed a transceiver. Therefore, in a typical embodiment, processor 526 is responsible for tuning the transceiver to the appropriate carrier in order to carry out the processes of figures 2, 3, and 4.

While the many aspects of the present invention are susceptible to various modifications and alternative forms, specific examples thereof have been shown by way of example in the drawings and are herein described in detail. It should be understood, however, that the invention is not to be limited to the particular forms or methods disclosed, but to the contrary, the invention is to cover all modifications, equivalents, and alternatives falling within the scope of the appended claims.